BLM LIBRARY
88081490

ESSENTIALS OF PLACER SAMPLING

Remarks by John Wells*

Presented at BLM Minerals Management Workshop and Seminar

Portland, Oregon - March 4, 1976

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225

*Mining Engineer, Denver Service Center

#15297978l
D:88081490
TN
421
.W45
1976

PART I

Sampling

I. GENERAL

In BLM work - one of the mineral examiner's functions is to give a qualified opinion as to whether or not a mineral deposit or mining claim has present or potential value. Perhaps the first evidence to be examined and weighed in forming this judgement will be the evidence of value indicated by sampling. For this reason, a discussion of placer valuation should start with sampling. Placer sampling is too involved to detail here but because of its importance in the valuation process, some general observations will be made and the essential features highlighted. Procedural details are given in BLM Technical Bulletin No. 4, and in references listed at the end of this paper.

First, it is important to distinguish between sampling for the purpose of initial valuation, and sampling to block out a finite parcel of mining ground. It sometimes takes only a few intelligently selected samples to determine that a property has no economic value. On the other hand, a potentially minable deposit may require an extensive sampling program to establish recoverable values, total volume and other information essential to planning an actual mining operation.

The latter is normally a responsibility of the miner, but an equally detailed investigation may be required within the Bureau in cases where private lands are taken by condemnation and the question of fair compensation is referred to the courts.

Representative placer samples are seldom easy to obtain. This fact reflects built-in problems relating to particle size, the high unit value of gold, and the erratic distribution of particulate gold in most deposits.

2. LARGE PARTICLE SIZE

Concerning particle size: The theory of sampling is that if enough small portions of a deposit, properly spaced, are taken, their average value will approximate that of the whole. But consider the extreme range of particle sizes to be dealt with in most placers. It is not unusual for a gravel deposit to contain large rocks or boulders weighing perhaps tens or hundreds of pounds each, as well as silt, sand and cobbles in varying sizes and amounts. When taking relatively small samples from such material there is a tendency to avoid areas containing large-size rock, or to otherwise include disproportionate amounts of fine material in samples, without considering the effect on calculated values. In either case the end effect is the same as salting a sample - a fact not recognized by some mineral examiners.

3. HIGH UNIT VALUE

Next, consider the high unit value of gold and its effect on sample calculations. In a commercial placer the ratio of gold to gravel (by volume) may be on the order of one part gold to 100 million parts of gravel.[1/] Because of this ratio, a slight error in the gold content of a small sample will appear as a large error in the calculated bank-run value. The effects are illustrated by Table I and Figure 1.

4. ERRATIC DISTRIBUTION OF VALUE

Obtaining satisfactory placer samples would be much simpler if the valuable minerals were uniformly distributed throughout the whole mass. In almost all placers, however, the heavy minerals are more or less segregated. In cases where economic values are confined to pay streaks, these are likely to occur as narrow, discontinuous accumulations with little or no value in between. Where coarse gold is present it is generally very erratic in distribution and under such conditions a reliable placer valuation will depend as much on observation and judgement, as on the sampling itself.

In theory this problem can be overcome by taking samples large enough to offset the eccentricities of a deposit, but to do so,

1/ Ground having a gold-gravel ratio of 1:100,000,000 (by volume) is worth approximately 45 cents per cubic yard (@ $100/oz.)

could mean taking samples measured in tons rather than pounds. In practice, taking such large samples is seldom feasible. Some argue that if enough small samples are taken the high values will balance the lows and when combined, provide an end figure representative of the deposit. In theory this may be true, but practical considerations seldom permit taking the number of samples needed to achieve this end.

TABLE I

EFFECT OF A SINGLE GOLD PARTICLE

ON PLACER SAMPLES OF TYPICAL SIZE

Channel cut or drill hole size (inches)	Size of gold particle and effect on sample, $ per cubic yard		
	20-mesh (6.57 mg)	40-mesh (0.91 mg)	60-mesh (0.27 mg)
3 x 6	$4.11	$0.57	$0.17
6 x 6	2.06	0.29	0.08
6 x 12	1.03	0.14	0.04
12 x 12	0.51	0.07	0.02
7½ dia.	1.68	0.23	0.07
5¼ dia.	3.43	0.47	0.14
3 dia.	10.47	1.45	0.43
16-in. pan*	3.43	0.47	0.14

*180 pans per cubic yard

Values shown are those which would result from one gold particle in a 1-foot sample increment and are based on 900-fine placer gold, with gold @ $100 per fine ounce. Gold weights (mg) shown for the various mesh sizes are averages determined by the writer.

5. EVALUATION OF RESULTS

The kind of sampling and evaluation procedures required will depend upon the type of deposit, the number of exposures available for testing and other factors. In any case, appropriate sampling and correct interpretation of data are essential for together, they provide the foundation upon which all succeeding conclusions must rest. Gold placer samples as generally taken do not establish absolute value but if properly interpreted and used, they provide a sound basis for reliable decisions. For this reason, established placer mining companies put their exploration and evaluation work in charge of employees who have had wide experience with the type of deposit or mining project involved. In brief, successful placer companies place as much reliance on the experience and insight of their prospecting and management personnel as they do on the sample results per se. If there is a substitute for experience-based judgement, the operating companies have not found it.

6. MINERALS OTHER THAN GOLD

It should be mentioned that placers chiefly valuable for minerals other than gold are generally easier to sample and evaluate than gold placers. Minerals such as rutile, zircon and ilmenite have a relatively low unit value and also, they make up a relatively

large part of the deposit. In such placers, extraneous particles of low-value mineral entering a sample have a relatively small effect on calculated values. Also the fact that such minerals are commonly found in small-grained materials such as beach sand, makes it easier to obtain representative samples.

7. SAMPLE PROCESSING

No dredge or other large-scale placer equipment saves 100 percent of the bank-run value. The manner in which placer samples are processed should reflect this fact. In other words, the sample should be processed in a way that indicates the recoverable value rather than absolute mineral content. When dealing with gold placers, samples are usually washed in a pan, rocker, sluice or in a comparable gravity concentration device which properly used, will indicate the commercially recoverable gold content of a sample.

After a sample has been washed and reduced to a black-sand concentrate, the concentrate is placed in a pan with a globule of mercury which picks up the gold. As a final step, the gold and mercury are separated by dissolving the mercury in nitric acid. From the amount of gold recovered and the volume of the sample, the value per cubic yard is calculated.

Where monazite, zircon, rutile, ilmenite or other heavy minerals are of interest, the black-sand concentrate must be processed in special ways which may include high tension separation, low and high-intensity magnetic separation or other procedures designed to separate the minerals of interest into commercial-grade products.

Where the heavy minerals of interest have inclusions of foreign substance, or are attached to rock particles, separation into salable-grade products may not be feasible. The point to be stressed is that standard assay procedures do not reveal such conditions and for this reason, the valuation of heavy mineral concentrates should not be based on chemical analyses alone.

Details for the treatment of placer samples are given in Bureau of Land Management Technical Bulletin 4, and in other references listed at the end of this paper.

8. OTHER FACTORS

Aside from indicating the mineral content of a deposit, a sampling program should provide other information needed for economic evaluation. The mineral value in itself may be of secondary concern where sampling or examination of the lands show unfavorable bedrock conditions, excessive amounts of sticky clay, large boulders or other

factors that would adversely affect a placer mining operation. A good sampling program will reveal such conditions, should they exist. The Feasibility Study is discussed in Part Two of this paper.

9. NUMBER OF SAMPLES REQUIRED

There is no fixed rule for the number of samples or drill holes needed to adequately test a piece of placer ground. Speaking generally, spotty ground will require more samples than ground in which values have a somewhat general distribution. Physical conditions, richness, and size of the deposit are factors to be considered, but in the end, personal judgement must be relied on. The first sampling may be of a cursory nature sufficient only to determine if further interest is warranted. Where preliminary sampling is encouraging, subsequent investigation or exploration should progress through a series of carefully evaluated steps designed to give a decisive answer at the end of each step.

Placers are commonly explored by means of test pits or small shafts, or by drilling. How much time and expense are needed to systematically explore a deposit is obviously a question of its size, physical characteristics and purpose of the investigation. In shallow ground containing little water, test pitting or trenching with a backhoe or bulldozer usually will be the cheapest and fastest method of gaining

access for sampling. Where the ground stands well, suitable channels cut vertically in the exposed walls are commonly relied on for an initial evaluation. When coupled with experience, samples of this type can provide a reliable basis for estimating the size and tenor of the deposit as a whole.

Sampling large placers, particularly dredge deposits, is almost always accomplished by the use of drills. Power-driven churn drills equipped with heavy steel drive pipe and special placer tools are employed. The fact that almost all gold dredging projects have been based on the results of churn drill sampling is significant. Placer drilling and related procedures are detailed in Bureau of Land Management Technical Bulletin 4.

When prospecting narrow, stream-type deposits the holes are usually drilled at relatively close intervals along lines laid out at right angels to the general trend of the deposit. In widespread placers, holes are generally put down at the intersections of a rectangular grid designed to suitably test the deposit.

Finally, for purpose of calculation, the sampled area is divided into geometric units small enough to permit reliable averaging of component data. The yardage and value of each unit is then determined

and combined to give a total yardage and an average mineral content for the deposit as a whole. Typical drill patterns and methods for calculating the volume and value of a deposit are illustrated in BLM Technical Bulletin No. 4.

A word of caution. At first glance, placer drilling and evaluation appear to be relatively simple procedures but in practice - this is not so. A particular difficulty relates to theoretical vs measured sample volumes. As the drill casing is driven downward it will in theory, cut a cylinder of gravel having an area equal to that of the drive shoe and a length equivalent to the drive. But in practice, a perfect core is rare and we find the measured core rise or the volume of sample recovered from each drive to be greater or less than their theoretical amounts. When drilling gold placers these deviations become important - because when basing calculated values on relatively small-diameter holes and a high-value mineral, any discrepancy between the theoretical and actual sample size becomes critical. For this reason, excess or deficiency of core should be taken into consideration during the calculating procedure and suitable corrections applied. Stated simply, if a drill-hole increment contains too much core its indicated value will have to be downgraded. If it contains too little core the end value may be upgraded. Placer drilling

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225

requires specially trained personnel and it should be remembered that "correcting" the drill results is a specialty outside experience of most exploration engineers. For this reason, any placer valuation based on drilling should be viewed critically until the qualifications of the person in charge have been established. This is particularly true where the original drill logs are not available for inspection or where values indicated by drilling cannot be compared against past production from the particular deposit or area. In brief, the evaluation of sample results from placer drilling is not a simple arithmetic process. In many cases indicated values need interpretation followed by experience-based adjustments.

On the other side of the coin - the sampling of large gold placers by use of properly equipped and operated (churn) drills under the supervision of qualified personnel has produced reliable results and today, remains as a standard exploration procedure within the dredging industry.

10. PITFALLS

When evaluating gold placers the mineral examiner should be aware of certain pitfalls. The most dangerous are:

Use of uncased or small-diameter drill holes.

Fire assay (or atomic absorption assay) of placer samples.

Splitting samples.

Uncased or Small-Diameter Drill Holes: Drilling procedures routinely employed in hard rock exploration can cause serious error when applied to gold placers. Because the gold content of most commercial placers is less than 1 part gold to 100 million parts of gravel, small-diameter drill holes are extremely sensitive to stray gold particles and to errors in measured or assumed sample volumes. The nature of this problem is shown by Figure 1. Also in Figure 1, it can be seen that any sloughing of an uncased drill hole within a gold-bearing zone will tend to upgrade the calculated value by significant amounts. If the quantity of extraneous material (entering an uncased hole) and its source could be precisely determined, suitable adjustments could be made when calculating sample values.

But experience tells us that in dealing with gold placers, small-diameter uncased drill holes give unreliable results. Most often, the ground will be overvalued.

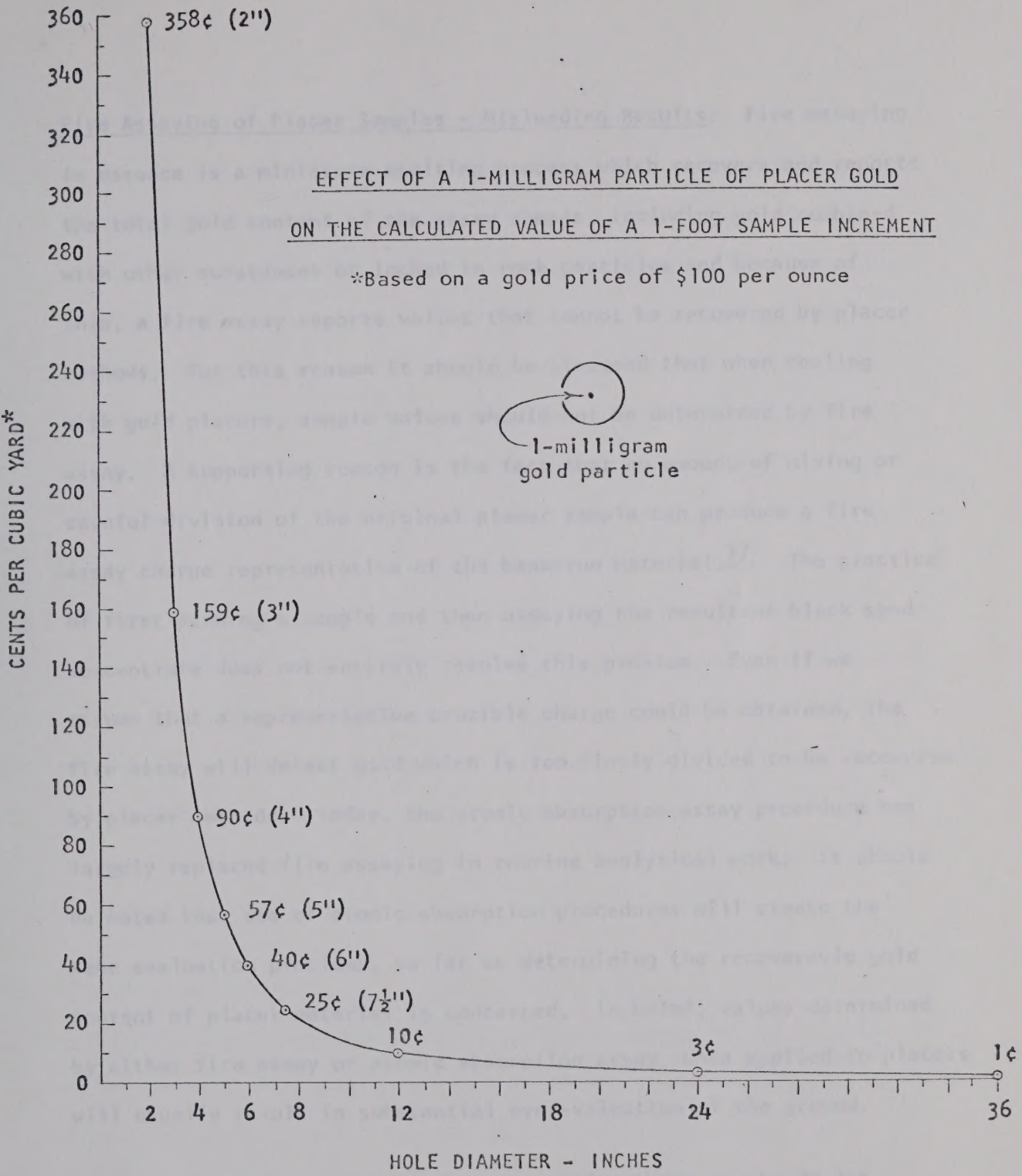
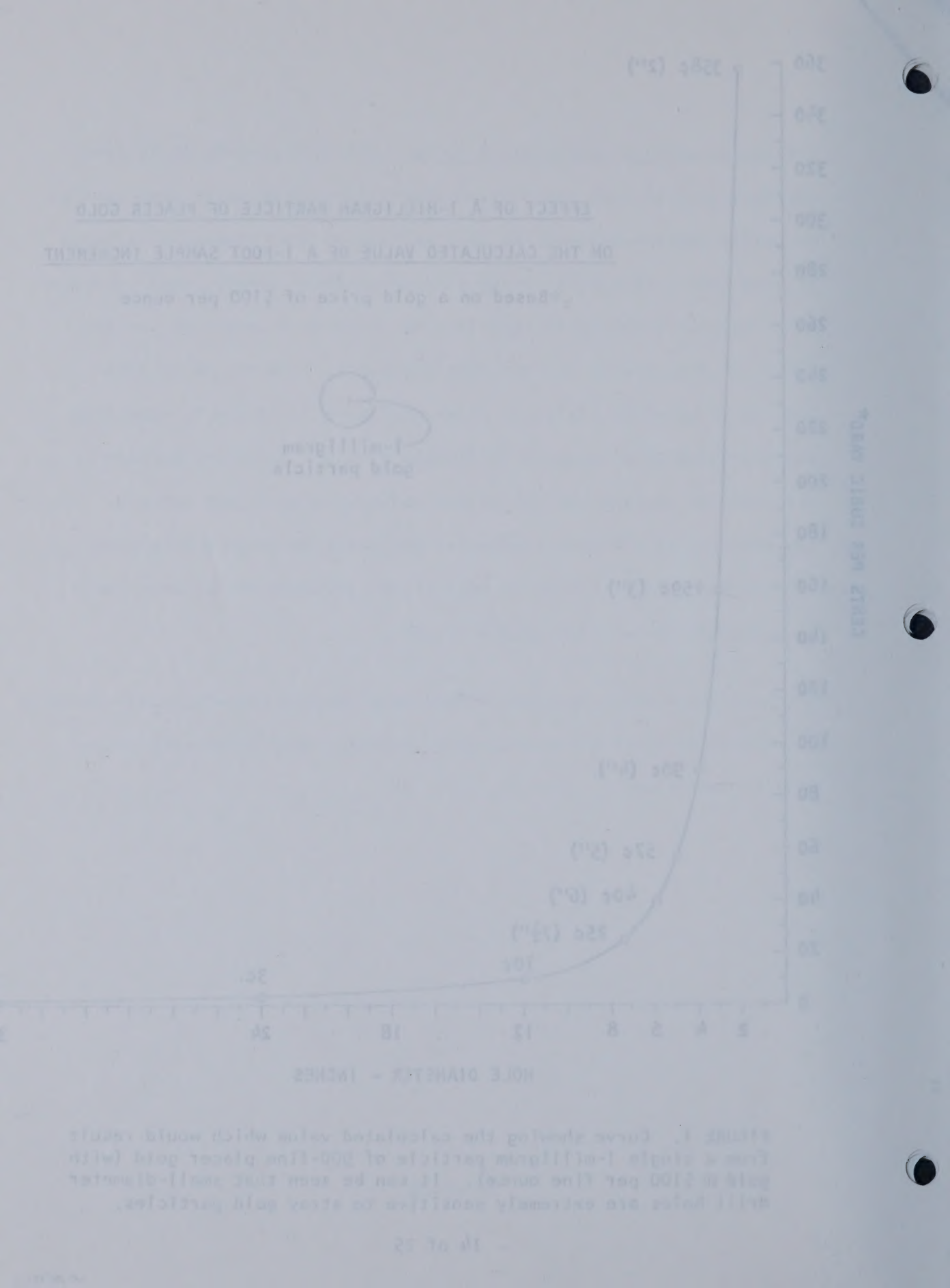


FIGURE 1. Curve showing the calculated value which would result from a single 1-milligram particle of 900-fine placer gold (with gold @ $100 per fine ounce). It can be seen that small-diameter drill holes are extremely sensitive to stray gold particles.

J.A.W.
2-13-76



Fire Assaying of Placer Samples - Misleading Results: Fire assaying in essence is a miniature smelting process which recovers and reports the total gold content of the assay sample, including gold combined with other substances or locked in rock particles and because of this, a fire assay reports values that cannot be recovered by placer methods. For this reason it should be stressed that when dealing with gold placers, sample values should not be determined by fire assay. A supporting reason is the fact that no amount of mixing or careful division of the original placer sample can produce a fire assay charge representative of the bank-run material.1/ The practice of first panning a sample and then assaying the resultant black sand concentrate does not entirely resolve this problem. Even if we assume that a representative crucible charge could be obtained, the fire assay will detect gold which is too finely divided to be recovered by placer methods. Today, the atomic absorption assay procedure has largely replaced fire assaying in routine analytical work. It should be noted that use of atomic absorption procedures will create the same evaluation problems, so far as determining the recoverable gold content of placer material is concerned. In brief, values determined by either fire assay or atomic absorption assay, when applied to placers will usually result in substantial over-valuation of the ground.

1/ The amount of sample used for a crucible charge may be 29.166 grams or more commonly, 14.583 grams.

Splitting Samples: When dealing with lode deposits it is customary to reduce each sample from its original bulk to a small-volume pulp prior to assaying. This is generally done by progressive crushing and splitting. The amount finally taken for assay or other analysis may weigh only a few grams. But when dealing with placers, the entire sample is normally used for analysis. Typically, the total sample is washed to produce a heavy-mineral concentrate from which the gold or other heavy mineral is extracted for weighing. In a gold placer the valuable mineral content is so small and its distribution is so uneven, any attempt to proportionately divide a sample by taking alternate shovels, mechanical splitting, or by other means is likely to yield erratic results. As a rule, gold placer samples should not be split or otherwise divided before washing. On the other hand, when dealing with fine-size placer materials having a low unit value, such as magnetite or ilmenite-bearing sands, a substantial reduction of the bulk sample (or of its concentrate) by mixing and splitting may be an acceptable practice.

II. POINTS TO REMEMBER

Textbooks stress the importance of taking a representative portion of the deposit when cutting a sample. In dealing with gold placers, this is seldom possible. For the reasons mentioned - just how

Splitting Samples: When dealing with lode deposits it is customary to reduce each sample from its original bulk to a small-volume pulp prior to assaying. This is generally done by progressive crushing and splitting. The amount finally taken for assay or other analysis may weigh only a few grams. But when dealing with placers, the entire sample is normally used for analysis. Typically, the total sample is washed to produce a heavy-mineral concentrate from which the gold or other heavy mineral is extracted for weighing. In a gold placer the valuable mineral content is so small and its distribution is so uneven, any attempt to proportionately divide a sample by taking alternate shovels, mechanical splitting, or by other means is likely to yield erratic results. As a rule, gold placer samples should not be split or otherwise divided before washing. On the other hand, when dealing with fine-size placer materials having a low unit value, such as monazite or ilmenite-bearing sands, a substantial reduction of the bulk sample (or of its concentrate) by mixing and splitting may be an acceptable practice.

II. POINTS TO REMEMBER

Textbooks stress the importance of taking a representative portion of the deposit when cutting a sample. In dealing with gold placers, this is seldom possible, for the reasons mentioned - just how

"representative" or how meaningful a particular sample is - will generally be a matter of inference. In turn, the reliability of an inferred value will reflect the experience and insight of the sampler, or of those who would read meaning into his findings.

PART II

The Feasibility Study

I. GENERAL

If a placer valuation is to have real meaning, the mineral examiner must look beyond the question of cubic yards or cents per yard. He must recognize that regardless of sample values, a cubic yard of gravel in the ground is worth nothing if it can't be mined. Obstacles to mining may be physical or they may be statutory. In some cases, mining problems in the form of unfavorable bedrock, sticky clay, boulders or other physical impediments will outweigh the question of mineral content. Today, laws pertaining to surface protection generally, and to water quality in particular, must be considered in any placer mining plan.

A feasibility study is essentially the part of a mineral investigation that looks at the minability of a deposit in a practical way. There are many cases where a detailed study is not required. Either the prospect is too lean, or insurmountable mining problems are evident from the start. Where a property is clearly worthless but an official checking is required, the fatal points are documented and summarized in a brief but adequate presentation of facts. On the other hand, where a viable project appears in the balance, <u>all</u> pertinent factors must be recognized and each must be correctly weighed.

PART II

The Feasibility Study

In addition to showing the technical feasibility of a project the feasibility study should indicate the magnitude of capital expenditure required and how much profit can be expected. The fact that specific cost data may not be available at this stage should not preclude a preliminary estimate of costs and profit. It can be seen that as a practical matter, the person responsible for a feasibility study should have a thorough knowledge of placers and of the various placer mining methods, including their limiting features. Where the evaluation involves bucket-line dredging, there is no substitute for an experienced placer engineer familiar with the particulars of dredging.

2. ELEMENTS OF A FEASIBILITY STUDY

A placer feasibility study is usually started with the reconnaissance, and where justified, is progressively refined as the over-all investigation proceeds. In effect it is a sieve through which the evaluator sifts his acquired data until only the essentials remain. It may incorporate many, or comparatively few steps, depending on the complexity of a case or the experience and insight of the investigator. But regardless of the number of steps or degree of inquiry, all should lead to a correct conclusion.

Features that influence the feasibility of a project and the choice of a mining method include:

1. Type of deposit
2. Size of deposit
3. Recoverable value
4. Topography
5. Water Supply
6. Bedrock conditions
7. Thickness and type of overburden
8. Geographic location and climate
9. Legal impediments
10. Environmental constraints

The foregoing list is not complete. It is inserted here to illustrate the kind of data which may be needed for an adequate feasibility study. When the range of inquiry has been established the next step is to investigate and weigh its constituent parts, starting with those most likely to be controlling features. In this regard - one of the first things to consider is the question of muddy water. Muddy water or more precisely - the control of muddy water - represents a major obstacle to placer mining in the United States.

So far as large-scale placer mining is concerned, one of the most constrictive pieces of legislation ever enacted is the National Environmental Policy Act, signed on January 1, 1970. Subsequent legislation and a plethora of rules, regulations and water quality standards administered at the Federal level by the Environmental Protection Agency, or at the State level by EPA-approved agencies such as The Department of Environmental Quality in Oregon - have placed severe obstacles in the path of any would-be placer miner. BLM mineral examiners should be acquainted with present Federal and State laws and with local ordinances pertaining to surface mining, mined land reclamation, water quality control, etc. In addition you should keep up-to-date on EPA regulations and proposed regulations (published in the Federal Register) so far as they affect the mineral industry. Individually and collectively, environmental regulations are an essential part of any feasibility study. In particular, placer examiners should be familiar with provisions of the Federal Water Pollution Control Act which as amended in 1972, restructured the authority for water pollution control and consolidated authority in the Administrator of the Environmental Protection Agency. (See reference at end of this paper.)

Part Two of the November 6, 1975, issue of the Federal Register contains EPA's 'interim final' rules on effluent limitations for the ore mining industry. Referring to placer mining, including dredging and hydraulicking, these rules state that total suspended solids (in a point source effluent) shall not exceed 50 milligrams per liter maximum for any one day, and shall not exceed an average daily value of 30 milligrams per liter for 30 consecutive days. These amounts are equivalent to 1 pound of suspended solids in 2,400 gallons, and 1 pound in 4,000 gallons respectively. For practical purposes, this is clear water.

Placer mining normally generates large quantities of muddy water so regardless of sample values - if for technical or other reasons this water cannot be contained, clarified, or otherwise brought into compliance with EPA effluent regulations - in the absence of a special discharge permit, the property has no value as a mine.

PART III

Points To Remember

Where a mineral property is dormant, or a mere prospect; mineral examiners employed by the Bureau of Land Management face a particularly difficult task. Here - the valuation often must be based on minimal sample data - but this in itself should not preclude a correct judgement.

When samples are taken from irregular-spaced points, the interpretation of sample results will require a large measure of common sense, or in other words, an intelligent perception of what each sample means. Although such samples do not determine absolute volume or unit value, they can, if properly selected, indicate the range of values within the deposit. Coupled with experience samples of this type provide a basis for estimating the size and grade of the deposit as a whole.

The size of sample to be taken is relative. In the end, it must be determined by judgement after considering the type of deposit, available exposures and purpose of the investigation. An adequate sample may require a few pounds or several tons. Although a single sample is not sufficient basis for valuation of a deposit - there are many cases where after the examination is complete - the final analysis and valuation will depend on a few critical samples.

In brief, honest sampling requires good judgement and practical experience. The thought to be carried in mind throughout any placer sampling program is to obtain key information which can be used as a guide for additional investigation - should it be warranted.

SUGGESTED REFERENCES:

Daily, A., "Valuation of Large Gold-Bearing Placers", Engineering and Mining Journal, July 1962, pp. 80-88.

Doheny, L.C., "Placer Valuation in Alaska", Engineering and Mining Journal, Dec. 1941, pp. 48-49; Jan. 1942, pp. 43-44; Mar. 1942, pp. 48-49. (Includes prospecting in frozen ground).

Smith, R.G., "The Discrepancy Between Drilling and Dredging Results", Engineering and Mining Journal, Nov. 19, 1921, pp. 812-815.

Wells, J.H., "Placer Examination, Principles and Practice", Tech. Bull. 4, 1969 & 1973, Bureau of Land Management.

Wolff, E.C., "Handbook for the Alaskan Prospector", 2d ed., Mineral Industry Research Lab., Univ. of Alaska, College. pp. 236-265 (Placer drilling).

RELATED ARTICLES:

Kline, M.H., "Evaluation of Monazite Placer Deposits", RMO-908, 1952, U.S. Atomic Energy Commission.

Romanowitz, C.M., Bennett, H.J., and Dare, W.L., "Gold Placer Mining: Placer Evaluation and Dredge Selection", I.C. 8462,1970, U.S. Bureau of Mines.

VanSickle, Gordon and Lakin, Hubert, "An Atomic-Absorption Method for the Determination of Gold in Large Samples of Geologic Materials", U.S. Geological Survey Circular 561,1968. (Describes a laboratory method for determination of placer gold in 100-gram samples.)

WATER QUALITY CONTROL:

O'Brien, Brice, "The New Water Pollution Control Act", Mining Congress Journal, March, 1973, pp. 36-45. (An analysis of the Federal Water Pollution Control Act of 1972 - from the standpoint of the mining industry.)

"Interim Final Rules on Effluent Limitations for Ore Mining-Dressing." Federal Register (Part 2) for November 6, 1975, pp. 51722-51737.

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225

BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225